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Original Article

Examination of Gait and Balance Parameters Between Genders

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Authors' Contribution: A: Study design, B: Data collection, C: Data analysis, D: Manuscript preparation, E: Discussion and conclusion

ABSTRACT

Study aim(s): This study aimed to examine the relationship between dynamic balance and gait parameters, focusing on gender differences. Specifically, it sought to determine the presence of asymmetry between the right and left side in dynamic balance control among healthy individuals, as well as to explore the influence of age, gender, and anthropometric characteristics on dynamic stability. Additionally, the study examined the relationship between dynamic balance and spatial-temporal gait parameters.
Methods: The study population consisted of 66 volunteers (33 female, 33 male participants), all leading sedentary lifestyle. The average age of the female participants was 30.58±6.275 years, while that of the male participants was 30.39±4.899 years. Participants first completed a sociodemographic form. Following this, a static balance test was performed using the D-Wall apparatus in a bipedal stance, both with eyes open and closed. The test was conducted three times, with the mean value recorded. Afterward, participants rested passively for five minutes before the commencement of the gait analysis. In the initial phase of the investigation, a walking analysis was conducted barefoot at a velocity of 4.0 km/h (SCX version) on the Walker View device. During a one-minute trial at this speed, the following variables were recorded for one minute at 4.0 km/h: lower extremity trunk, hip, and knee flexion range of motion; stride lengths, cadence, and contact times. The collected data were then analyzed using an independent t-test.
Results: The mean body mass index (BMI) was 21.77±1.071 kg/m² for women and 24.08±2.246 kg/m² for men. A significant difference was identified in the trunk flexion range of motion (ROM), favoring men, and in eyes-open static bipedal balance, favoring women ($p < 0.05$). No significant differences were observed in the remaining parameters ($p > 0.05$).
Conclusion: The results demonstrated significant discrepancies between male and female participants in trunk flexion ROM, where men outperformed women, and in eyes-open static balance, where women outperformed men. These findings indicate that gender is an important factor to consider in dynamic balance and gait assessments.

Keywords: Gender, Gait, Joint Kinematics, Balanc

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INTRODUCTION

The term "human postural stability," or balance, refers to an individual's ability to maintain an upright posture while managing both internal and external disturbances [1]. Balance is evaluated either in a fixed position (static balance) or in motion (e.g., during walking). Research on static balance has focused on the necessity of maintaining the center of mass (CoM) within the limits of the base of support (BoS), examining this aspect in both healthy individuals and those with various pathologies [2]. The base of support (BoS) is defined as the area outlined by the outer borders of the feet, which determines the range of possible positions the center of pressure (CoP) can occupy. The CoP, in turn, represents the point of origin of the ground reaction force [3]. Conversely, to move forward, the center of mass CoM must move beyond the limits of the BoS in three-dimensional space, predominantly in the sagittal plane. This creates a greater challenge for maintaining balance under dynamic conditions [4].

The precise mechanisms underlying dynamic balance control still remain unclear. The neurophysiological symmetry between the right and left legs in healthy individuals remains a topic of contention. Generally, a noticeable symmetry in terms of stride length and tempo of movement has been observed between the legs [5]. Some studies suggest that gait asymmetry may arise due to pathologies in the motor system [6-8]. However, other studies indicate that differences in movement patterns between the right and left legs naturally occur during bipedal gait [9, 10]. As a result, the issue of gait symmetry or asymmetry in healthy individuals remains an unresolved area of research [11].

In a study by Nolan et al. (2005), the authors investigated standing balance in children aged 9 to 16 years, revealing age and gender differences. The study showed that girls demonstrated superior balance control compared to boys at ages 9-10. However, as they grew older, boys demonstrated more rapid in balance control. These findings suggest that boys may have slightly delayed development in postural control compared to girls. Therefore, it is essential to consider gender differences when examining children's balance performance [12].

The TecnoBody Walker View (Bergamo, Italy) is a device that allows for the analysis of gait patterns in individuals walking at their own pace on a treadmill. The Walker View assesses the range of motion (ROM) of the trunk, hips, and knees, as well as step length, cadence, and contact time. It uses eight pressure sensors and three-dimensional camera sensors to gather data [13].

The TecnoBody D-Wall is a device that measures 16 key joint ranges of motion, balance, agility, strength, jump parameters, proprioception, and limited stabilization in individuals standing on a platform with pressure sensors in front of a screen. It can also be used for both rehabilitation and exercise through physical activities and exergames [14].

The objective of this study was to examine the relationship between dynamic balance and gait parameters, with a focus on gender differences. Specifically, the study aimed to investigate any asymmetry between the right and left sides in dynamic balance control among healthy individuals, as well as the effects of age, gender, and anthropometric characteristics on dynamic stability. The study also sought to explore the relationship between dynamic balance and spatial-temporal gait parameters. This study will also determine whether dynamic balance is a gender-dependent variable and contribute important insights to the literature on factors that should be considered in gait stability studies. The findings will help clarify whether dynamic balance is a gender-dependent variable and contribute valuable insights to the literature on factors influencing gait parameters.

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METHODS

Study model

This article describes an experimental study assessing static balance and gait dynamics. Participants completed a sociodemographic form, followed by static balance testing with the D-Wall device (eyes open and closed) and gait analysis using the Walker View device at 4.0 km/h, measuring parameters such as range of motion, stride length, and cadence.

The participants first completed a sociodemographic form. Following this, a static balance test was conducted using the D-Wall device in a bipedal position, both with eyes open and closed, repeated three times, and the mean value was recorded. Participants were allowed a passive rest period of five minutes before the gait analysis began. A preliminary trial was conducted using the Walker View device at a speed of 4.0 km/h (SCX version) without shoes to analyze the subject's gait. After the trial, the following parameters were recorded for one minute at 4.0 km/h: range of motion for the lower extremity trunk, hip, and knee flexion, as well as stride lengths, cadence, and contact times.

Participants

The study population consists of 33 females and 33 males with a sedentary lifestyle, all of whom volunteered to participate. The mean age of the female participants was 30.58±6.275 years, while the mean age of the male participants was 30.39±4.899 years. The inclusion criteria were as follows: participants had to lead a sedentary lifestyle and voluntarily agree to participate in the study. Exclusion criteria included individuals with foot deformities or a lower extremity limb difference exceeding 1 cm, those who had undergone lower extremity surgery within the past six months, individuals with neurological diseases, and those who had experienced at least one fall in the previous six months.

The Ethics Committee of Çankırı Karatekin University granted ethical approval for the study in 2024, under the protocol number (application code: 0023ddaea29645e5). Furthermore, the study was conducted following the principles outlined in the Declaration of Helsinki.

Data analysis

The analyses will be conducted using IBM SPSS Statistics Version 26.0 (SPSS Inc., Chicago, IL, USA). Continuous variables will be presented as the mean ± standard deviation, while categorical variables will be reported as the numbers and percentages. Descriptive statistics for quantitative variables and the distribution of qualitative variables will be analyzed using frequency analysis. The study will employ an independent t-test for calculations, with a statistical significance level set at $p \leq 0.05$ in two directions.

The required sample size for the study was calculated using the G*Power 3.1.9.7 software program. A sample size calculation was performed for the independent t-test, assuming a margin of error of 5% ($\alpha = 0.05$) and 80% power ($1-\beta = 0.80$). Based on these parameters, the total sample size required was determined to be 66 individuals [15].

FINDINGS

The study sample consisted of 33 females and 33 males. The mean age of the female participants was 30.58 ± 6.275 years, while the mean age of the male participants was 30.39 ± 4.899 years. The mean body mass index (BMI) for the female participants was 21.77 ± 1.071 kg/m², while the mean BMI for the male participants was 24.08 ± 2.246 kg/m². For further details, please refer to Table 1.

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Table 1. Sociodemographic data form

Variables	N	Female	Male
		X̄±SD	X̄±SD
Age (year)	33	30.58±6.275	30.39±4.899
Height (cm)	33	162.21±3.090	178.36±3.681
Weight (kg)	33	57.55±3.527	76.67±7.453
BMI (kg/m^2)	33	21.77±1.071	24.08±2.246

N; number of people, M; mean cm; centimeter, kg; kilogram, m; meter, SD; standard deviation

Significant differences were identified between the gait parameters of male and female participants, particularly in trunk flexion range of motion (ROM) and balance performance during a static bipedal position with eyes open ($p < 0.05$). However, no statistically significant differences were observed in the remaining measured parameters, as indicated by p-values exceeding 0.05. Comprehensive details and statistical results are provided in Table 2.

Table 2. Comparison of range of motion (ROM) parameters between genders

Variables	Female	Male	t	p	Cohen's d
	X̄±SD	X̄±SD			
Trunk Flexion ROM (°)	2.63±.671	2.74±.506	-.725	.001*	0.18
Right Hip ROM (°)	45.45±7.859	47.84±9.370	-1.122	.375	-0.27
Left Hip ROM (°)	42.84±8.343	46.44±8.783	-1.709	.881	-0.42
Right Knee ROM (°)	50.07±6.886	52.39±10.779	-1.038	.332	-0.25
Left Knee ROM (°)	51.97±4.227	54.54±8.923	-1.495	.006	-0.36

(°); degrees, cm; centimeters, sec; seconds, SD; standard deviation, min; minute, mm; millimeter (p<0.05)

Table 2 compares ROM between females and males, revealing significant differences in trunk flexion (p = .001, d = 0.18) and left knee ROM (p = .006, d = -0.36), although the effect sizes suggest minimal practical differences. Other measures, including right hip (p = .375), left hip (p = .881), and right knee ROM (p = .332), showed no significant differences, with small effect sizes favoring males. Overall, males had slightly higher ROM, but most differences lack both statistical and practical significance.

Table 3. Comparison of gait and balance parameters between genders

Variables	Female	Male	t	p	Cohen's d
	X̄±SD	X̄±SD			
Right Step Length (cm)	65.09±6.597	66.00±8.828	-1.495	.296	-0.11
Left Step Length (cm)	64.36±6.499	65.09±7.985	-.406	.767	-0.10
Cadence (min/step)	.87±.072	.88±.100	-.380	.245	-0.11
Right Step Duration (sec)	.74±.063	.76±.141	-.752	.111	-0.18
Left Step Duration (sec)	.74±.066	.77±.148	-.919	.057	-0.26
Eyes Open Bipedal Balance (mm^2)	147.98±67.293	185.77±127.80	-1.503	.001*	0.37
Eyes Closed Bipedal Balance (mm^2)	193.84±136.117	208.80±164.675	-.383	.603	-0.09

Table 3 reveals that males demonstrated significantly greater postural sway during eyes-open bipedal balance tasks compared to females (p = .001, Cohen's d = 0.37), indicating a moderate effect size for this specific variable. In contrast, the analysis of other parameters, such as step lengths, cadence, step durations, and eyes-closed balance, did not reveal any statistically significant differences between the genders ($p > .057$). Additionally, the effect sizes for these non-significant variables were minimal, suggesting that the observed variations were negligible. Overall, these findings indicate that the majority of gait and balance measures were comparable between males and females, with only limited gender-specific differences observed.

DISCUSSION

The findings indicate that there are gender-based differences in dynamic balance and gait characteristics among healthy young adults. Notably, males and females showed significant differences in trunk flexion ROM and static balance when tested with eyes open. While the exact causes of these differences remain uncertain, factors such as hormonal influences, muscle strength, and variations in body composition are thought to contribute.

This study investigated gender-based differences in dynamic balance and gait parameters among healthy young adults. The findings revealed substantial differences between male and female participants in trunk flexion ROM and static balance with eyes open. These outcomes highlight the importance of considering gender as a factor when assessing dynamic balance and gait characteristics.

The study supports the hypothesis that dynamic balance may differ between genders in healthy individuals, a result that aligns with prior research predominantly involving young adults. For instance, previous studies have indicated that females typically exhibit greater pelvic tilt and less trunk movement compared to males during walking (16, 17). These observed distinctions may be partially due to anatomical variations between genders, such as women's generally wider pelvis and greater femoral anteversion, in contrast to men's broader shoulders and longer legs [18].

Additionally, our findings align with earlier research, demonstrating no right-left asymmetry in dynamic balance control among healthy young adults. The lack of significant differences in step length between the right and left sides aligns with previous studies [17, 18]. However, one study reported that men had greater internal rotation during the support phase, whereas women had greater internal rotation during the swing phase [19]. This variation was attributed by the authors to gender-specific differences in muscle activation patterns.

It is important to acknowledge certain limitations of this study. Firstly, the sample size was relatively small. Secondly, the study focused solely on healthy young adults. Future research should investigate gender-related differences in dynamic balance and gait parameters in older adults or individuals with balance or gait impairments.

CONCLUSION

In conclusion, the study revealed significant differences in dynamic balance and gait parameters in healthy young adults. These findings underscore the importance of considering gender as a critical factor in the assessment of dynamic balance and gait. The study highlights the presence of gender-based differences in dynamic balance and gait characteristics among healthy young adults, with significant distinctions observed in trunk flexion range of motion (ROM) and static balance when tested with eyes open. These findings suggest that variations in anatomical structure, hormonal influences, and musculoskeletal factors may contribute to these differences, highlighting the complexity of gender-related biomechanics. Furthermore, the results align with prior research, demonstrating no significant right-left

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asymmetry in dynamic balance control, which supports the consistency of this pattern across multiple studies. This emphasizes the importance of accounting for gender as a critical factor in assessments and future investigations into balance and gait, particularly as these findings may inform clinical practices and interventions targeting diverse populations.

CONFLICT OF INTERESTS

No potential conflict of interest was reported by the authors.

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